MINISTRY OF LOCAL GOVERNMENT, HOUSING & CONSTRUCTION

REPORT OF THE COMMITTEE TO EXAMINE THE POLLUTION CAUSED BY VEHICLE EXHAUST EMISSIONS

CENTRAL ENVIRONMENTAL AUTHORITY

C. 89

Report of the Committee to examine the pollution caused by vehicle exhaust emissions

Central Environmental Authority
Maligawatte New Town
Colombo 10.

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POLLUTION CAUSED BY VEHICLE EXHAUST EMISSIONS

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The increasing incidence of belching vehicles on the roads of Colombo and in the outstations has caused nuisance to the public as well as raising concern as to the possible long-term detrimental effects which may occur on health and other aspects. In view of this concerns, the Hon. Prime Minister decided to appoint a Committee to examine the problems of pollution caused by vehicle exhaust emissions. The terms of reference of this Committee were as follows :

a. Examination of the overall position regarding the problems presently created by vehicle fumes and the benefits that can arise from reducing such emissions,

b.1 Examination of the impact of such emissions on :
- b.1.1 the health of the people and on the health services,
- b.1.2 the general urban environment and
- b.1.3 other factors

b.2 Examination of the impact of the causes leading to such emissions on :
- b.2.1 fuel consumption figures and
- b.2.2 other factors

c. Examination of the incidence of such emissions from road and rail traffic arising from :

c.1 normal use and wear and tear,

c.2 mechanical malfunction of types not included above and

c.3 other causes

d. Examination of the present legal position regarding the establishment of emission standards, prevention of fume - emitting vehicles on roads etc.

e. To make recommendations with reference to the abatement of the problem :

e.1 Technical applications,

e.2 Administrative arrangements

e.3 Legislation
e.4 Establishment of emission standards and testing and monitoring procedures,
e.5 Use of urban air pollution monitoring stations and
e.6 Other related aspects such as measures to reduce traffic congestion.

The Committee was to be chaired by a Member of the Central Environmental Authority and included representatives from :

a. the Ministry of Health,
b. the Ministry of Labour,
c. the Ministry of Transport,
d. the Sri Lanka Central Transport Board,
e. the Ceylon Institute of Scientific and Industrial Research,
f. the National Science Council,
g. the Automobile Association of Ceylon and
h. the University of Colombo

During the course of the investigation, changes of some individuals serving on the Committee took place, while many others assisted the Committee by providing information and advice. Names of those who served on and officials and members of the public who assisted the Committee are given in the Appendices and in the "Acknowledgements".

If was not possible, in the time and with the resources available, to investigate every aspect in the detail which the Committee would have desired. For example, to what extent is the discolouration of buildings due to belching vehicles and what effects may belching vehicles have on tourism ? Again, the haze or "smog" reported in recent times over the city of Colombo is believed to be the result of excessive vehicle exhaust emissions. What will be the effect of these air pollutants - for example, when they are washed down to earth during rainfall ? In many respects, reliable quantitative data was not available.

For these and other reasons, it was decided to structure the present report in the form of a "Base Report" to which Supplements could be joined at a later date. One such Supplement, for example, could examine the question of the advisability of reducing the levels of lead-containing additives in petrol. There is consideration being given to this question in many countries, including that of doing away altogether with the addition of lead-containing compounds.

It must, however, be noted that even in wealthy industrialised countries that have been endeavouring to improve the quality of their vehicle exhaust emissions for some decades already, unsatisfactory characteristics are still present in these emissions. It is the view of the Committee that if the recommendations made in this report are implemented, a very considerable improvement in the quality of the vehicle exhaust emissions currently in evidence in Sri Lanka should result. Recommendations for further improvements could then be issued as Supplements and with improvements and changes in technology this would no doubt be an on-going process.

Introduction

Transportation is a vital aspect in the life of any society. Its importance is such that the State, town council or other public body may find it necessary to assume at least part of the responsibility of ensuring the provision of adequate means of transport of the public and of goods and, sometimes, to subsidise the cost of the service in order to facilitate its use. Such arrangements are to be observed in both the industrialised and non-industrialised countries.

Conditions governing public transport in the non-industrialised countries often are influenced by certain special factors. They often have relatively high rates of population growth, necessitating frequent additions to the vehicle fleet in the public transport sector in order to keep pace with personal transport needs. When consumption and production increase, increases in goods vehicles are also required. Lack of finances or of foreign exchange may, however, lead to the purchase of used vehicles for the additions to the fleet or for replacements to existing stock. Finances or foreign exchange may be inadequate to purchase the spare parts necessary for the maintenance of vehicles in optimal condition or to provide adequate decentralised garage facilities. Technical staff may also be under strength to meet requirements and their number may be further depleted through emigration. Other factors such as congested roads may contribute to less efficient operation of transport services in poorer than in the richer countries.

Sri Lanka has witnessed a considerable increase in motor vehicular traffic in recent years. Among those operated in town and on the highways are CTB buses, private buses and coaches, vans, lorries (including pick-ups etc), bowsers, cars, motor-cycles and scooters and, occasionally, tractors. Although in other countries motor vehicles may be found running on fuels such as LPG (for example, taxis in Japan) or even producer gas, in Sri Lanka effectively all vehicles run on either petrol or diesel.

Together with the increase in motor vehicles on Sri Lankan roads, there has been experienced a considerable increase in air pollution due to vehicle exhaust emission gases. Even under good circumstances, an increase in air pollution is expected and experienced as the motor vehicle population expands. However, the increase in air pollution due to vehicle exhaust emissions in Sri Lanka is not in proportion to the increase in motor vehicle population but is considerably higher than would be expected or should be permitted.

The problems which can be caused by motor vehicle exhaust emissions have raised concern worldwide. The first approaches to regulate these emissions were by the Californian authorities in 1961. Despite the highly developed technical infrastructure available to the U.S. authorities as well as the benefit of large markets and some measure of influence on motor vehicle manufacturers in aspects such as modification of engine design, the attempt to "clean-up" motor vehicle exhaust emissions in the industrialised countries has been less than completely successful. In this connection it is appropriate to note the following observations :

1. "It has been pointed out that, when attempting to improve the motor vehicle environmental performance, "we are dealing with a sophisticated mass-produced machine, which is fuelled by a complex chemical, operated under diverse road and climatic conditions by motorists with a wide variety of living and driving habits, and serviced by mechanics who range from the expert to the incompetent and unscrupulous"" from :

"Environmental Guidelines for the Motor Vehicle and its use", UNEP - Industry and Environment Guideline Series, Volume 2, P. 5(1981) and "Regulating the Automobile", M.I.T., Boston (1977).

2. Paris, October 20, 1972.

Mr. Christian J. Herter
Chairman
Environment Committee
Organisation for Economic Cooperation
and Development.

Dear Mr. Chairman :

The AD Hoc Group on Motor Vehicles herewith submits its report, "Automotive Air Pollution and Noise : Implications for Public Policy".

Our aim has been to examine a broad range of issues raised by the spreading phenomenon of traffic- caused air pollution and noise. Many of the issues considered in the report require responses only at the national or local level. Some, however, have implications that reach out beyond the borders of any one nation. It is to the resolution of these latter issues that the Committee may wish to devote particular attention.

The report represents the Group's best judgement after more than a year of meetings, consultations and analysis. While no single member of the Group necessarily agrees with every specific statement or with the exact wording of each conclusion, the Group as whole endorses the full report. Given the controversial nature of the subject matter and the diversity of national viewpoints and interests, the Group takes considerable pride in having arrived at this broad consensus.

We submit our report in the hope that it may prove to be of value to the Committee and to other public officials in comming to grips with what has become a problem of growing concern in all OECD Member countries.

Yours sincerely,

Michel Frybourg
Chairman, Ad Hoc Group

A problem inherent in attempts to "clean-up"vehicle exhaust emissions is the number and diversity of pollutants present. Pollutants present in the exhaust emissions of petrol vehicles may include carbon monoxide, unburnt hydrocarbons, lead, oxides of nitrogen and particulates. Those present in emissions from diesel vehicles may include carbon monoxide, unburnt hydrocarbons, sulphur dioxide, oxides of nitrogen and particulates. Most of the pollutants take their origin from constituents of the fuel, but some of the oxides of nitrogen may arise from the reaction of atmospheric nitrogen under the conditions found in the engine. Burning of engine lubricating oil may occur to an appreciable degree in the combustion chamber of a diesel engine in a poor condition.

An exhaust emission where carbon monoxide and hydrocarbons have been essentially converted to carbon dioxide is considered to be satisfactory in this respect (although fears have been expressed elsewhere that the build up of carbon dioxide in the atmosphere may have the adverse effect of leading to a gradual rise in ambient temperatures). The reduction of levels of carbon monoxide and hydrocarbon emissions may be attempted by adjustments to the combustion process followed by the use of a catalytic converter attached to the exhaust system.

However, catalytic converters tend to get poisoned and ineffective when used with exhaust gases containing lead compounds (as is the case with petrol-driven vehicles in Sri Lanka). They also increase costs both to purchase and by decreasing fuel efficiency.

Much improvement can as a first step be achieved with many "belching" vehicles in Sri Lanka by improving the combustion process without having to resort to the attachment of catalytic converters.

Adjustments designed to improve the combustion of fuel may, however, have the adverse effect of increasing the production of oxides of nitrogen. The adverse health effects of the presence in the atmosphere of oxides of nitrogen or of sulphur are described in the appendices, but it should be noted that sulphur oxides and oxides of nitrogen have been implicated as causative agents of "acid rain" which has been causing considerable environmental damage (particularly in certain industrialised countries) in agriculture and forestry and to buildings etc. These substances may arise from different sources, such as fuel combustion in motor engines and the combustion in furnaces etc. of oil or coal. In Sweden, for instance, several thousand lakes have been very badly affected by "acid rain", which is also damaging many forests in Western Europe. Acid rain in Sri Lanka could have a damaging effect on her plantation economy in addition to effects on the catchment areas for the rivers and reservoirs.

Another outcome of air pollution which has frequently been experienced in industrialised countries is the formation of smog in or over cities. In 1984 the Sri Lankan aviator Mr. Ray Wijewardene, reported to us the observation of a layer of smog on certain days at an elevation of about 4000 feet over Colombo. It would appear very likely that this now regularly observed smog layer is contributed to by the growing air pollution load from vehicle exhaust emissions in Colombo.

Table I provides an indication of the rate of increase of registration of new vehicles by fuel type from 1970 to 1986, while Table II gives figures of domestic sales of petrol and auto diesel. While taking into consideration factors, such as the inclusion of motor cycles in the category of petrol vehicles and improvements in fuel consumption figures of recent models of vehicles, it is evident that fuel (and especially diesel fuel) consumption by motor vehicles has

Table I : Registration of new vehicles by fuel type from 1970-1986

Year	Petrol	Disel	Kerosene	Non-Fuel vehicles eg. trailer	Total
1970	3435	4310	5	1804	8834
1971	2303	1697	10	537	4547
1972	1834	2026	3	673	4536
1973	1625	1431	940	278	4274
1974	1753	1671	1194	368	4986
1975	1639	1678	320	348	3985
1976	2935	1846	159	422	5362
1977	4386	3677	67	696	8826
1978	13198	9669	41	1306	24214
1979	27376	12374	181	2463	42394
1980	42099	17726	100	3851	63776
1981	24184	12036	36	1135	37391
1982	19401	9453	21	606	29481
1983	23677	12722	8	769	37176
1984	23310	14691	16	846	38863
1985	30069	15184	3	647	45903
1986	34126	12169	1	678	46974
Total (1970-1986)	257350	134360	3105	16707	411522
%	62.54	32.65	0.75	4.06	100

Source : Dept. of Motor Traffic, Narahenpita.

Table II Petroleum Corporation volume of trade - domestic sales ('000' metric tonnes)

Year	Super Petrol	Regular Petrol	Super Petrol & Regular Petrol	Auto Diese
	1	2	(1 + 2)	3
1970	91.048	57.363	148.41	254.530
1971	84.266	53.280	137.546	249.580
1972	81.069	50.693	131.762	264.173
1973	81.460	48.375	130.195	260.865
1974	64.380	30.504	94.884	243.926
1975	69.813	25.244	95.057	245.515
1976	77.412	23.653	101.065	257.557
1977	89.336	22.155	111.491	261.988
1978	112.961	17.033	129.994	308.792
1979	108.678	6.468	115.146	349.404
1980	107.691	-	107.691	397.710
1981	109.028	-	109.028	420.912
1982	114.183	-	114.183	444.428
1983	117.490	-	117.490	462.324
1984	118.831	-	118.831	481.174
1985	121.578	-	121.578	488.497
1986	130.263	-	130.263	487.431.

Source : Petroleum Statistics of Sri Lanka 1970-1980
Planning and Economics Section Ceylon Petroleum
Corporation 1981 September.

increased considerably in recent years.

The values of sales of Super Petrol and Auto Diesel for 1983 were as follows :

Product	Unit	Quantity	Value Rs.
Super Petrol	Litres	154,360,873	1,853,182,690
Auto Diesel	Litres	546,460,203	3,984,539,888

Source : Ceylon Petroleum Corporation

These figures are of much relevance to the present discussion since a vehicle that is "belching" is emitting substances which have not been fully burnt and which therefore still contain usable energy. Should a "belching" vehicle lose between 10 to 20% of its fuel unburnt, the monetary cost of this would be significant. A number of (diesel oil-burning) SLCTB buses are observed to belch and it is noteworthy that supplies of diesel fuel made directly by the Ceylon Petroleum Corporation to the SLCTB in 1983 were 121,563,000 Litres of value Rs. 884,211,044 (source : CPC).

It is thus apparent that excessive vehicle exhaust emissions have effects not only on health but, also on economic aspects. It should be noted as well that a badly belching vehicle may also obscure visibility to the extent of increasing the likelihood of traffic accidents. Exposure to carbon monoxide over a period even at low concentrations tends to cause drowsiness and to slow down reaction times which would also contribute to road hazards. It may also be argued that the frequent occurence of badly belching vehicles may also affect tourism, standards of hygiene and other aspects which are not readily quantifiable.

The present document may be regarded as a "Base Report" to meet some pressing needs. Supplements may be prepared from time to time to address special problems, such as the desirability of eliminating lead in petrol.

Some Problem Areas and Recommendations

Some topics related to air pollution by motor vehicles are discussed in the following pages and recommendations to mitigate problems are made. Since certain recommendations (eg. development of an electrified rail system for Colombo and the suburbs) can only be considered in a longer time frame, these will need more extensive studies.

A. Exhaust emissions

In addition to smoke, the exhaust emission may contain carbon monoxide, hydrocarbons, particulates, oxides of sulphur, oxides of nitrogens, lead etc. At present, criteria of excessive exhaust emission are those of obscuring visibility, while evidence may be obtained by holding a blotting paper to the exhaust emission.

It is recommended that initially some smokemeters be imported for the use of the Department of Motor Traffic, Police Department, SLCTB, Department of Private Omnibus Transport and the Ceylon-German Technical Training Institute. Preferably these instruments should be of the same make and model to facilitate the setting of standards, training in use etc. Once adequate experience with these instruments is obtained in Colombo, further smokemeters may be considered necessary for use outstation.

While much improvement of the existing situation should be possible with the use of smokemeters, consideration should be given as the next stage for the purchase of equipment to measure rapidly and reliably other selected pollutants such as carbon monoxide. Suitable standards would need to be laid down and staff trained in the operation of these instruments. The instruments may be used for testing (a) in the field and (b) in garages.

The CEA should also obtain a mobile air pollution testing laboratory for field work.

B. Fuel quality

The lead content and sulphur content in fuel oils may cause pollution problems. Lead compounds are added to petrol after refining, while sulphur is present in crude oil and diesel fuel.

Lead is presently added in Sri Lanka to petrol as tetraethyl lead. The range is from 0.34 to 0.55 grams lead per litre (normally 0.35 g/L). Permitted lead maxima in petrol in some other countries are as follows :

Country	gram lead per litre
UK/France/Italy/Denmark/Finland/ Netherlands/Austria	0.40
West Germany/Norway*/Sweden*/Switzerland*	0.15 (*Premium)
Portugal	0.635
Yugoslavia	0.60
Belgium	0.45
Spain	0.48 (Premium)

(Source : CPC)

There has been discussion and controversy in recent years about the need to eliminate the addition of lead to petrol. Some of the arguments for and against the reduction or elimination of lead from petrol are given in the appendices. A decision on this matter for the Sri Lanka context after full consideration of aspects of environment, cost etc needs a special investigation.

Permitted sulphur levels in fuels marketed by the C.P.C. are as follows :

Product	S content % wt
Super petrol	Max. 0.10
Auto diesel	Max. 1.1
Kerosene	Max. 0.2
Fuel Oil	Max. 3.5 to 4.0

It is recommended, in view of the effects of emission of oxides of sulphur into the atmosphere, that the CPC keep a strict control on the sulphur contents of the fuels it markets and of crude oil purchases.

The CEA should monitor lead and sulphur contents, as appropriate, in crude oil shipments and refined fuels as supplied to the public regularly.

C. Fuel injection spares

In our inquiries, complaints have been noted as to the costs of fuel injection spares and test rigs. It is recommended that customs duty on these items be removed, particularly since the financial savings to the nation on fuel, health costs etc. will exceed the customs duty received on these items.

Bulk order discounts for fuel injector spares, diesel filter elements etc may be obtainable if channeled through a State Agency.

D. Vehicles

A system should be worked out of phasing out older vehicles, which are in unsatisfactory condition. This should be implemented by introduction of Ministry of Transport (M.O.T.) testing of vehicles at regular intervals (see also section F).

E. Improved driving conditions

Since poor driving conditions, such as congested streets, stop-and-start traffic etc., lead to poor fuel utilisation, traffic flows should be improved.

Measures to be taken could include reducing the importation of vehicles and enforcing regulations such as no-parking of lorries in congested streets. New vehicles permitted to be imported should, as far as possible, be those with built-in systems for regulation of exhaust emissions.

F. Vehicle inspection and licensing

All vehicles should be tested and a Fitness Certificate obtained at least once an year. The Fitness Certificate should be produced at the Registrar of Motor Vehicles before the annual Revenue Licence is issued. The Fitness Certificate should incorporate the name of the official who physically tested the vehicle and be displayed on the windscreen together with the Revenue Licence. The Fitness Certificate and Revenue Licence should be sufficiently small so as not to obstruct vision. All buses, vans and lorries should be inspected and certified every six months. The Fitness Certificate for the second half of the year should be of a different colour or shape.

The Fitness Certificates should be issued by licensed garages. In the inspection procedures should be incorporated compression testing, fuel injection system testing and exhaust emission testing. For combined testing and certification the garage may charge an appropriate fee. The permitted fees should be periodically reviewed by the Registrar of Motor Vehicles.

It has been found that fuel injection pumps which have been correctly set may be tampered with, with the aim of getting more power (to enable overloading, to increase manoeuverability in traffic etc.)

To hinder tampering, a seal should be placed on each fuel injection pump after it is set. This should be inspected by police on spot checks of belching vehicles.

It is recommended that a Testing and Certification Book be introduced and this should be carried in the vehicle. This will carry records of (a) testing and certification and (b) offences.

Garages should be encouraged to drain out (diesel) tanks once or twice yearly to minimize damage to fuel injection systems due to water and sludge.

It is recommended that garages which are found to have given false certificates be prosecuted and (or) have their authority to issue certificates cancelled.

Training should be given to people to enable them to test and calibrate fuel injection systems for diesel engines ("test-rig operators"). This may be done, for example, at the Ceylon-German Technical Training Institute. Following successful completion of the training, a certificate should be issued to the qualified test-rig operator. Each licensed garage should have at least one qualified test-rig operator on its staff and a satisfactory air-conditioned dust-free room to house and operate the equipment.

G. Penalties

Presently there is provision for imposing fines up to a maximum of Rs. 200 on offending drivers. But the fine imposed is frequently well below the maximum provided.

It is recommended that a mandatory fine of Rs. 1000 is imposed on an owner of a belching vehicle for the first offence and a mandatory fine of Rs. 2000 for the second and each subsequent offence. A smaller fine may be imposed on the driver, as well. The fines should be noted in the appropriate section of the Testing and Certification Book.

Offending Vehicles should also be served with an Order of Prohibition (with copies to the Police and Commissioner of Motor Transport). This Order would be in the form of a windscreen "sticker" which could be removed on compliance. A grace period of 14 days should be given for the necessary repairs. If the repairs are not completed in 14 days, the Police may prosecute. The vehicle may not be used for other than driving to the garage or for test purposes, while the Order of Prohibition is in force. Following a conviction, the driver and supervisor/owner of the vehicle should be required to attend a traffic lecture given by a "Traffic-trained" officer.

H. Education

The CEA should conduct an educational campaign through the media, schools etc relating to pollution by vehicle exhaust emissions and related aspects.

I. Long-term action

1. Development of a plan for an electrified rail system for Colombo and the suburbs.

2. Investigate the possibilities of the increased transport by water of passengers and goods.

3. Investigate the feasibility of gas operation for certain categories of vehicle, e.g. liquified petroleum gas (LPG), liquified natural gas (LNG) or compressed natural gas (CNG).

4. Keep under review developments in respect of electrically-operated vehicles such as buses.

Summary of Principal Recommendations

1. Smokemeters of a reputable make should be imported urgently for use by the Department of Motor Traffic, Police Department, SLCTB, Department of Private Omnibus Transport and the Ceylon-German Technical Training Institute and placed in service without delay (page 11).

2. Equipment to measure other selected air pollutants such as carbon monoxide should also be obtained (page 11).

3. The CEA should obtain a mobile air pollution testing laboratory for field work (page 11).

4. The feasibility of discontinuing the addition of lead compounds to petrol should be kept under review (page 12).

5. The CPC should keep a strict control on the sulphur contents of the fuels it markets and of crude oil purchases (page 12).

6. The CEA should monitor lead and sulphur contents, as appropriate, in crude oil shipments and refined fuels regularly (page 13).

7. Customs duties on fuel injection spares and test rigs should be removed (page 13).

8. A scheme should be drawn up for phasing out older vehicles which are in unsatisfactory condition (page 13).

9. Measures must be taken to improve traffic flows on the streets (page 13).

10. All vehicles should be inspected and a Fitness Certificate obtained at least once a year (page 13).

11. All buses, vans and lorries should be inspected and certified every six months (page 14).

12. The Fitness Certificates should be issued by licensed garages (page 14).

Training programmes should be made available on testing and calibrating fuel injection systems for diesel engines. Each licensed garage should have on its staff at least one qualified test-rig operator (page 15).

13. A seal should be placed on each fuel injection pump after it is set and this should be inspected by police on spot checks of belching vehicles (page 14).

14. A Testing and Certification Book should be introduced and carried in the vehicle (page 14).

15. A mandatory fine of Rs. 1000 is recommended on an owner of a belching vehicle for a first offence and a mandatory fine of Rs. 2000 for a second and subsequent offence. A smaller fine may be imposed on the driver as well (page 15).

16. Offending vehicles should be served with an Order of Prohibition. If repairs are not completed in 14 days, the Police may prosecute (page 15).

17. Following a conviction, the driver and supervisor/owner of the vehicle should be required to attend a traffic lecture (page 15).

18. The CEA should conduct an educational campaign relating to pollution by vehicle exhaust emissions and related aspects (page 15).

19. Long-term aspects should be developed and/or reviewed regularly such as the increased transport by water of passengers and goods and the development, where feasible, of the use of electrically-powered rail and road transport (page 16).

20. The feasibility of gas operation for certain categories of vehicles should be investigated and kept under review (page 16).

Appendix 1

Composition of the Committee

The following officials were members of the Committee in the course of this investigation :

1. Dr. R.H. Wickramasinghe, Working Member, CEA (Chairman)
2. Dr. R.P. Jayawardene, Director-General, Natural Resources, Energy and Science Authority
3. Dr. H.M.S.S.D. Herath, Senior Medical Officer, Ministry of Health
4. Mr. W. Jayasuriya, Commissioner of Motor Traffic

   succeeded by

   Mrs. Kotakadeniya, Commissioner of Motor Traffic, Ministry of Transport
5. Mr. E.E.B. Perera, Senior Deputy Inspector General of Police
6. Mr. J.M.L.M. Peiris, Transportation Superintendent (Motive Power) Ceylon Government Railway
7. Mr. A. Dullewe, Engineer, Automobile Association of Sri Lanka (AA of Sri Lanka)

   and

   Mr. D.M. Weeratunge, Secretary, AA of Sri Lanka
8. Mr. B.D.Y. Seneviratne, Director (Technical) and General Manager Sri Lanka Central Transport Board (SLCTB)

   succeeded by

   Mr. D.D.S. Jayawardene, Technical Controller, SLCTB
9. Dr. S. Hettiarachchi, Department of Chemistry, University of Colombo
10. Dr. E.R. Jansz, Deputy Director, Ceylon Institute of Scientific and Industrial Research (CISIR)

    and

    Dr. P. Jegatheeswaran, Senior Research Officer, CISIR

    succeeded by

    Dr. A.P. Mathes, Officer-in-Charge, Environmental Science and Technology, CISIR
11. Mr. M. Ponnambalam, Deputy Commissioner of Labour (Division of Occupational Hygiene)
12. Mrs. M. Wickramasinghe, Senior Assistant Legal Draftsman, Ministry of Justice
13. Mr. M. Elayaperuma, Secretary, Ministry of Transport
14. Mr. E.W.M. Perera, Secretary, Ministry of Private Omnibus Transport
15. Dr. Milton Munidasa, Consultant
16. Mr. L.J.P. Fernando, Environmental Officer, CEA
17. Mrs. S.E. Yasaratne, Environmental Officer, CEA

Appendix 2

Officials who assisted the Committee

The following officials also attended meetings of the Committee and participated in the discussions.

1. Mr. E.E. JeyaRaj, Director (Environmental Protection), CEA
2. Mr. N. Barsenbach, Technical Examiner, Department of Motor Traffic
3. Mr. F. Burke, Asst. Superintendent of Police, Traffic Police Department
4. Mr. C.C. Selvaratnam, Chairman, Sub-Committee on Traffic, Automobile Association of Sri Lanka
5. Mr. D.T. Jayamanne, Research Officer, Department of Labour (Division of Occupational Hygiene)

Acknowledgements

In the course of the present investigation, a number of expert opinions in various subject areas were obtained. Acknowledgement must be made, in particular, to the following who gave generously of their time and expertise to provide information and helpful suggestions.

1. Her Excellency M. Abeysekere, Ambassador of Sri Lanka in Thailand
2. Mr. P.A.M. Deraniyagala, Senior Mechanical Engineer, Colombo Commercial Company (Engineers) Ltd
3. Mr. J.P. Obeysekera, Motoring Correspondent, "The Island Automag", "Island" Newspaper
4. Mr. V. Wijetunge, Attorney-at-Law
5. Mr. C. Ratwatte, Attorney-at-Law
6. Dr. C.G. Uragoda, Physician-in-Charge, Central Chest Clinic
7. Staff at the Ceylon-German Training School, Moratuwa
8. Mr. J. Diandas, Transport Advisor
9. Mr. S. Sivasunderam, Deputy General Manager (Planning and Development), Ceylon Petroleum Corporation
10. Mr. C.S.A. Fernando, Vice President, Ceylon Society for the Prevention of Accidents
11. Mr. P.R. Wijewardene, Engineer and Aviator
12. Dr. M. Munasinghe, Energy Advisor to H.E. the President

The secretarial assistance of Mrs. Lakmali Brainerd is also gratefully acknowledged.

Annexure A.

VEHICLE EMISSION CONTROL SYSTEM

Introduction -

There are three areas from which pollutants are emitted on an uncontrolled vehicle

(a) Exhaust System (b) Crankcase (c) Fuel System

A number of modifications have been made by Manufacturers of Motor Vehicles to control the amount of pollutants emitted from vehicles.

Sources of Emissions :

During the combustion process in an automotive engine, some of the fuel fails to burn and is discharged into the engine crankcase or exhaust system. Additional hydrocarbons are emitted into the atmosphere. Of the total hydracarbons coming from uncontrolled automobiles, about 25% are emitted from the crankcase, 20 % from the fuel system and 55% from the engine exhaust.

In addition to hydrocarbons, carbon monoxide and oxides of nitrogen are also formed during the combustion process. These are also discharged into the exhaust system.

Exhaust Emissions :

The exhaust of a petrol automobile engine contains three significant air pollutants ; carbon monoxide, unburned hydrocarbons, and oxides of nitrogen, it also contains small amounts of solid matter - called particulates - made up largely of lead compounds from the tetraethyl lead used to increase the octane rating of the petrol. Carbon monoxide,(CO) Automotive exhaust is a major source of this substance. On the basis of weight alone carbon monoxide accounts for most of the pollution from automobiles. Although carbon monoxide presents no serious problems in rural areas, in the crowded inner city areas of large cities it is of concern to some environmentalists because under certain circumstances "pockets" of it can build up when large number of vehicles are on the streets. But recent studies have shown that these "Pockets" of carbon monoxide are not nearly as great a threat to human health as had been previously suspected. The carbon monoxide output of automobiles in conjested areas in the city is declining due

to the effectiveness of the emission control systems on cars, and this decline will continue as even better control systems are installed.

Exhaust Emission Control Systems - Controlled Combustion Systems (CCS) Components Carburettor

The carburettor has been recalibrated to give a leaner mixture of a better quality particularly at idle or during low speed operation.

Idle Stop Solenoid :-

The idle stop solenoid allows the throttle valve to close almost completely from the normal engine idle position and so starves the engine of fuel and air. This feature assists in reducing the possibility of engine run-on. The solenoid is deactivated when the ignition switch is turned off. As the operation of the idle solenoid determines the engine idle speed it is important that the accelerator is depressed about half way down while the engine is being started.

Automatic Choke (8 Cylinder Engines only) :

The Automatic choke is operated by a bi-metallic coil, which is heated by exhaust gas drawn from the exhaust cross-over passage that runs through the inlet manifold. As the coil heats up the choke progressively comes out of operation.

Exhaust Heat Valve :

The exhaust heat valve directs an additional flow of exhaust gas around the inlet manifold during the engine warm-up period. This improves fuel vaporisation during cold starts.

Distributor :-

The advance curve of the ignition distributor has been altered to meet the new emission limits.

Ignition Coil (6 Cylinder Engines Only) :-

The output of the ignition coil has been increased to improve the quality of the spark.

Cooling System Thermostat :-

The thermostat opening temperature has been revised to meet the requirements of the system during engine warm-up.

Air Pre-Heat (A.P.H.) System :-

This system provides a supply of pre-heated air to the carburettor until the engine compartment air temperature reaches a pre-set level.

Pre-heated air is supplied from the exhaust manifold heat stove via the hot air duct to the underside of the air cleaner assembly snorkel. A thermal vacuum valve controls the operation of a vacuum motor which operates the control damper assembly, and this regulates the amount of air supplied from the exhaust manifold stove.

The installation of this system ensures better engine response during the engine warm-up period also leaner fuel settings can be used, which assists in reducing engine emissions.

Vacuum Advance Control (V.A.C.) System :-

The basis of this system is the control of the vacuum available to the distributor's vacuum advance mechanism dependent on operating conditions.

The system includes the following three components :

(a) Cold feed Switch (C.F.S.)
(b) Transmission Control Spark System (T.C.S.S.)
(c) Thermal Vacuum Switch (T.V.S.)

Cold Feed Switch : (C.F.S.) -

Vacuum advance is denied to the distributor during engine warm-up. When the cylinder head temperature reaches 68°C the switch closes allowing vacuum to the Transmission Control Spark System.

Transmission Control Spark System (T.C.S.S.) :-

When the transmission is in top gear, ported vacuum is allowed to the distributor. A vacuum delay valve is incorporated with the VB engine.

Thermal Vacuum Switch : (T.V.S.) -

When the cooling water temperature reaches 104° C, the T.V.S. directs

full vacuum to the distributor allowing the engine to run cooler at idle and in the low gears.

Exhaust Gas Recirculation (E.G.R.) System :-

This system introduces controlled quantities of exhaust gas into the inlet manifold resulting in lower peak combustion temperatures in the combustion process which, in turn, reduces the formation of nitrogen oxides.

Crankcase Emissions :-

Emission of hydrocarbons from the engine crankcase is another source of automotive air pollution. This emission occurs in the following manner. During the combustion process in all petrol engines, some gases escape past the piston rings and into the crankcase. These gases consist mainly of unburned fuel. This "blow-by" occurs because of the very high pressures in the combustion chambers.

Crankcase Emission Control System : - Positive Crankcase Ventilation (P.C.V.) System

The purpose of the system is to draw the blow-by gases out of the crankcase, into the intake manifold system and thus recycle these gases through the combustion process in the cylinders.

Air is drawn through a filter in the air cleaner and on down through the crankcase where it mixes with the crankcase gases caused by engine blow-by. From here the gases are drawn from the crankcase via a spring-loaded, vacuum control valve into the inlet manifold to be burned in the normal combustion process.

Evaporative Emissions :-

Another source of emissions from automobiles is evaporation of petrol. This occurs, not only when the fuel tank is being filled, but at other times, even when the vehicle is not, in operation. Special systems to control evaporation have recently been developed, and are now installed in all vehicles.

Evaporative Emission Control (E.C.C.) System :-

The heart of this system is the canister in the engine compartment, which contains activated charcoal granules.

When the engine is not running, fuel vapours from the fuel tank are prevented from entering the atmosphere by the charcoal in the canister where they are absorbed.

Connected to the canister via vent lines are the fuel tank and the carburettor fuel bowl (except the 5.0 litre V8 carburettor where the fuel bowl is sealed.)

A vacuum purge line connects the canister to the inlet manifold via the carburettor. When the engine is running the vacuum draws air into the canister, and the absorbed fuel vapour is drawn from the charcoal, forming a mixture with the air which is burnt in the engine combustion process.

The venting system of the fuel tank incorporates a liquid/vapour seperator and a non-vented fuel tank cap. Intergral in the cap is a pressure/vacuum relief valve to cater for any differences of pressure or vacuum that may arise.

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Annexure B.

HEALTH ASPECTS OF POLLUTION OF THE ATMOSPHERE BY VEHICLE FUMES

1. INTRODUCTION

Atmospheric pollution is caused by emissions from a large number of sources : by smoke, gases and grit from domestic and industrial chimneys, locomotives and ships ; by gaseous pollutants from chemical works and industrial processes; and by exhaust gases from motor vehicles. Pollution from vehicular emissions is chiefly found in the metropolitan and urban areas where the number of motor vehicles is rapidly increasing. With the increase in vehicle density the dangers to health from pollution by vehicle fumes has assumed importance chiefly due to concern about the presence in exhaust emissions of known toxic chemicals such as carbon monoxide, lead, sulphur dioxide, oxides of nitrogen and unburnt hydrocarbons.

The following is a brief account of the known biological effects from toxic chemicals present in emissions from motor vehicles.

2. EFFECTS ON MAN OF TOXIC CHEMICALS IN VEHICLE FUMES

2.1 Carbon Monoxide :

Exhaust emissions from petrol-powered motor vehicles constitute the most important source of carbon monoxide (CO) in the atmosphere at breathing level. The rate of emission of CO from this source depends on such variables as the type of vehicle, its mode of operation and its speed. Concentrations in urban areas are closely related to the density of traffic and show peaks during 'rush hours'. Concentrations fall sharply with increasing distance away from the street.

Carbon monoxide forms strong bonds with the iron atom of the protohaem complex of haemoglobin forming carboxyhaemoglobin (HbCO) thus impairing the oxygen carrying capacity of blood ; the dissociation of oxyhaemoglobin is also altered due to the presence of HbCO in the blood thereby further impairing the oxygen supply to the tissues (the affinity of haemoglobin for CO is about 240 times that for oxygen).

The effects on health of high concentrations of CO are widely known. Much attention has, however, been given in recent times to possible effects of exposure to low concentrations of CO which result in blood HbCO levels of 10 percent or less. There is now much published evidence to suggest that comparatively low levels of HbCO produced by exposure to low concentrations of CO in ambient air can cause adverse effects to health. Experimental and epidemiological studies have highlighted several areas of concern.

As CO acts primarily by its interference to oxygen transport, and the nervous system is more sensitive to hypoxia than other systems of the body, much work has been done on the effects on psychomotor function by assessing the impairment of vigilance, perception, and the performance of fine tasks following exposure to concentrations of CO too low to produce clinical signs and symptoms. There is some suggestion that CO contributes to impairment of psychomotor function. However, the evidence is inconclusive, and further studies are indicated (1).

The damaged heart and respiratory system have been found to be prone to impairment by CO. In patients suffering from angina pectoris, a reduction in the time of onset of angina on excercise has been demonstrated when the HbCO levels exceeded 2.5 percent (2). Similar effects have been demonstrated in patients with intermittent claudication from peripheral vascular disease, where the onset of pain occured after a relatively shorter duration of exercise (3). It is likely that others such as the anaemic, those with cerebrovascular disease, and the elderly may be adversely affected by similar HbCO levels.

It has long been known that elevated levels of HbCO affected the working capacity of healthy individuals; levels of 40-50 percent are known to prevent work entirely. Recent work has shown that limitation of working capacity in healthy subjects appeared at HbCO levels of 4 percent with incapacity increasing with exposure to higher HbCO levels (4.5).

A tentative range of HbCO concentrations of 2.5 - 3.0 percent is recommended by WHO as the limit for protection of the general population including those with impaired health (6).

2.2 Lead

The contribution of alkyl lead additives in motor fuels accounts for the major part of all inorganic lead emissions. Over 70 percent of this lead is likely to enter the environment immediately after combustion; the rest is trapped in the crank-case oil and in the exhaust system of the vehicle. The degree of pollution from the combustion of alkyl lead depends on the car density.

Studies have shown that 35 percent of airborne lead inhaled by man is deposited in the lungs from whence it is absorbed. A major component of the lead absorbed accumulates in bones and teeth, the amount increasing throughout life. A smaller component is distributed in the soft tissues, including the blood. In the evaluation of lead exposure the concentration of lead in the blood is relied on as an index of exposure to hazardous conditions both in the occupationally exposed and in the general population. It has been shown that, on continuous exposure, every microgram of lead per m³ of air would contribute to an elevation of the blood level by about 1.0 - 2.0 micrograms/dl of blood. Elimination of lead from the body is mainly by way of urine (76 percent) and the gastro-intestinal tract (16 percent). A small fraction (8 percent) is excreted by sweat, the exfoliation of the skin and the loss of hair. The concentration of lead in deciduous teeth provides a useful long-term record of lead exposure in children ; it has been shown that concentrations of lead in the dentine of suburban school-children is considerably less than that in urban children who have been exposed to higher concentrations of atmospheric lead. There is increasing interest in the possibility of using hair as an index of exposure.

The biological effects of lead have been characterised in some detail ; several organs and systems are known to be affected.

The haemopoietic system shows effects at much lower blood lead levels than any other system. Lead interferes with the synthesis of haemoglobin at several enzymatic steps in the biosynthesis of haem, particularly by the inhibition of the enzymes ALAD and haem synthetase, resulting in anaemia. A simplified sequence of reactions affected by lead is shown in Fig. 1. The major effects of lead on haemopoiesis.

Fig. 1 Simplified sequence of Haemoglobin synthesis

Succinyl Co A + Glycine

↓ ALAS

amino-laevlulinic acid (ALA) → Increased ALA in Urine

↓ ALA dehydratase (ALAD) - Inhibited by Lead

Porphobilinogen

↓

Uroporphyrin III

↓

Coproporphyrin III (CP) → Increased Coproporphyrin in Urine

↓

Protoporphyrin IX

Fe → Haem synthetase - inhibited by Lead

Haem + globin → Haemoglobin

that are readily measured are the rate of excretion of ALA and CP in the urine. However, the effect of lead that correlates well with the concentration of blood lead is the inhibition of the enzyme ALA dehydratase. In general blood lead levels exceeding 10 micrograms/dl show perceptible inhibition of ALAD; whilst perceptible increases in Urinary ALA and CP as well as the appearance of anaemia are detected at much higher levels of over 40 micrograms/dl.

The effect of lead on the central nervous system leading to lead encephalopathy is associated more with childhood lead poisoning than with poisoning in adults. The reason may be due to the ease with which lead crosses the blood-brain

barrier in children. The clinical features of lead encephalopathy range from symptoms of restlessness, headaches and irritability to more severe sings and symptoms of delirium, mania, paralysis and coma. Death is not uncommon in severe cases, and those who survive may show residual neurological damage. There has been concern recently about the occurrence of subtle neurological damage in young children resulting in behavioural disorders without the appearance of lead encephalopathy; but several psychometric studies have failed to provide conclusive evidence (7,8). The effects of lead on the peripheral nervous system leading to lead palsy in occupationally exposed groups cited in the old lead literature is rarely seen even in industry today.

Effects of lead on the kidney are of two distinct types ; one, a reversible tubular defect which leads to interference in the absorption of glucose, amino acids and phosphates causing glycosuria, amino aciduria and hyperphosphaturia (Fanconi's Syndrome) : and the other, characterised by sclerosis and interstitial fibrosis eventually leading to renal failure. These effects are rarely encountered even in industry today.

In the gastro-intestinal system, colic and constipation are fairly consistent early signs which always accompany other signs of poisoning.

For most of the above conditions, sufficient data are not available to define dose-effect relationships, but blood levels below which specified effects have not been reported are defined by W.H.O. (9). Such no-detected effect levels in relation to blood lead levels are shown in Table I. These values may be useful for setting safe environmental standards.

TABLE I

No-detected-effect levels in terms of Blood Lead Levels (Micrograms/dl)

No-detected-effect level	Effect	Population
Less than 10	Erythrocyte ALAD inhibition	Adults, Children
40	ALA excretion in urine	Adults, Children
40	CP excretion in urine	Adults
40	Anaemia	Children
40 - 50	Peripheral Neuropathy	Adults
50	Anaemia	Adults
50 - 60	Minimal brain dysfunction	Children
60 - 70	Minimal brain dysfunction	Adults
60 - 70	Encephalopathy	Children
more than 80	Encephalopathy	Adults

Source : W.H.O. Environmental Health Criteria for Lead 1977.

2.3 Sulphur dioxide and Particulate Matter

The emission of sulphur dioxide and particulate matter from motor vehicles is relatively small when compared to that from domestic and industrial sources. But since these emissions occur close to ground level within the breathing zone, they can contribute appreciably to the total amount inhaled. At points close to mixed traffic, smoke from diesel engines makes a substantial contribution to suspended particulate matter in the air; the contribution from petrol-powered vehicles is insignificant.

Sulphur dioxide is catalysed by certain other atmospheric pollutants to form sulphur trioxide, sulphuric acid and sulphates-all of which have varying irritant effects on the respiratory system.

Inhaled Sulphur dioxide is highly soluble in the aqueous surfaces of the respiratory tract, and is therefore, absorbed in the nose and the upper air ways where it exerts its irritant effect as well; little of it reaches the lungs. In addition to irritation of the upper airways, high concentrations can cause laryngotracheal and pulmonary oedema sometimes leading to death. Sulphuric acid mist and some sulphates are more powerful respiratory irritants than Sulphur dioxide and produce similar but more severe effects.

Although controlled exposures to different concentrations have shown varying effects on respiratory function, epidemiological studies have provided much of the information concerning the effects of exposure to realistic concentrations of sulphur dioxide and suspended particulate matter. The most dramatic effects on mortality have been the sudden increases in the number of deaths that have occured during episodes of exposure to high concentrations, notably in the Meuse Valley in 1930, in Donora in 1948, and in London in 1952. People with pre-existing heart disease and lung disease, and the elderly were the most affected. In the London episode which lasted five days, about three times more than the expected number of deaths occured during and immediately after the event. The levels of sulphur dioxide and smoke were noted to have reached 3700 micrograms/m^3 and 4500 micrograms/m^3 respectively (10). Subsequent studies carried out to assess the mortality from moderate daily variations have revealed a relative increase in mortality with increases in concentration of sulphur dioxide and smoke (11). Evaluation of the findings from these studies has shown that increased mortality among the chronically sick could be expected starting at atmospheric concentrations of sulphur dioxide and smoke of 500 micrograms/m^3 and 500 micrograms/m^3 respectively. Morbidity studies, on the other hand, have shown that worsening of the conditon of patients with pre-existing respiratory disease could be expected at sulphur dioxide and smoke concentrations of 250 micrograms/m³ and 250 micrograms/m³ respectively.

In the general population, increased respiratory symptoms and decreased respiratory function, as well as an increased incidence of respiratory illnesses in children have been observed(12). Evaluation of these studies indicate that these effects could be produced at much lower concentrations of sulphur dioxide and smoke of 100 micrograms/m³ and 100 micrograms/m³ respectively (13).

The possibility of air pollution being a causal factor in the increased incidence of cancer of the lung has given rise to concern, due to the excessive occurence of lung cancer in urban populations, and the presence of carcinogenic substances such as polycyclic hydrocarbons in suspended particulates. Although some studies indicate a probable association, the Royal College of Physicians reviewed this issue and concluded that the evidence against such an association was stronger than the eivdence for it (14). It is now generally accepted that the upward trend in the incidence of lung cancer is best explained by the causal role of cigaratte smoking rather than by the presence of carcinogens in ambient air.

2.4 Oxides of Nitrogen

The major source of man-made emissions of oxides of nitrogen is the burning of fossil fuels; transportation sources, especially petrol powered vehicles, contribute as much as 50 percent to the total emissions in some countries.

Oxides of nitrogen are irritant gases which are less soluble in aqueous surfaces than sulphur dioxide. The effects on the respiratory system are therefore seen in the lungs and the lower airways as the aqueous surfaces of the upper airways retain only small amounts of the inhaled oxides of nitrogen.

Information on the effects of the oxides of nitrogen has been obtained mainly from controlled human studies and from industrial exposure; epidemiological studies on community exposure are difficult to interpret due to the likelihood

of observed effects being due to the presence of other pollutants.

Controlled human studies have shown that concentrations of oxides of nitrogen exceeding 1300 micrograms/m³ caused functional changes in healthy subjects-particularly an increase in airways resistance. Inadvertent exposure to high concentrations have been reported in occupational exposures; in these situations severe acute as well as delayed effects causing pneumonia, bronchiolitis and pulmonary oedema have been described (15). From these studies, it has been estimated that short term exposures ranging from 47 to 140 mg/m³ can cause pneumonia and bronchitis, while concentrations from 560 to 440 mg/m³ may cause fatal pulmonary oedema (16). High concentrations of this magnitude are not likely to be experienced in community exposures.

W.H.O. has proposed concentrations of 190 - 320 microgram/m³ for short-term exposures not exceeding one hour for not more than once a month. Concentrations for long-term exposures have not been proposed due to inadequate data (16).

3. CONCLUSION

The biological effects on humans of atmospheric pollution have been intensively studied for many years in developed countries and a vast body of literature is available. Many of these studies refer to pollution also from other sources such as industrial and domestic effluents. Emissions from vehicle fumes can, however, contribute appreciably to atmospheric pollution especially in urban areas where the vehicle density is high. It is, therefore, an important area of concern.

Atmospheric pollution from whatever source, whether industrial, domestic or vehicular, should be controlled because of its harmful effects on humans; enforcement and education, together with the employment of engineering and other scientific measures are needed for its control. With the pace of industrialisation and increase in vehicular traffic the problem of atmospheric pollution in Sri Lanka is likely to require the attention and control of the Environmental Authority.

Data available from the above studies may be useful in formulating environmental standards.

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Annexure C.

POLLUTION CAUSED BY VEHICLE EXHAUST EMISSION GASES

Environmental conditions are likely to deteriorate more seriously in city areas where traffic growth will be more pronounced than elsewhere. Within such areas, air pollution will be spreading in space and time as well as in intensity under the influence of continued suburban growth. Rising numbers of people will be exposed to high levels of air pollution more frequently. Urban pollutant concentrations vary considerably, depending on time and locations. Reliable assessment of the scope and intensity of vehicle air pollution in the city can only be made after analysing the detailed data on air quality. More accurate and more complete monitoring of air quality (which is being done at present) is therefore needed before a clear picture of the dimensions of the acute air pollution problem can be obtained.

Moreover, the health effects of automotive pollutants-particularly of low level exposure over long periods of time-are not well understood. While it is generally acknowledged that these pollutants are harmful in very high concentrations there is no agreement on thresholds of harm. The case for limiting vehicle emissions rests not on evidence of physical harm but rather on the growing feeling that it is in the public interest to minimize all emissions suspected of having adverse effects on man's health, well-being and environment.

Limiting vehicle emissions at source by setting and enforcing standards is the prevailing form of action adopted by the governments of developed countries to combat the problem of automobile air pollution. Differences in the severity of air pollution due to variations in the level of car use and in climatic conditions between the countries and differing national views as to the adverse effect of ambient levels of CO, NO_x and HC explains the existence of different emission control requirements.

Evidence obtained from manufacturers and other sources suggest that the cost of reducing emissions will rise steeply once a certain level of emission control has been obtained. Just how far beyond such a point it is appropriate to go will depend on assessment of the incremental benefits that would flow from the additional expenditures.

No adverse changes in driving performance are expected from present European emission controls. In the US, however, retarded ignition timing and leaner fuel/air ratios have already affected the drivability of some models, causing engines to stall more often and vehicles to hesitate during rapid acceleration. In addition, reduction in fuel economy is also incurred as a result of lowering compression ratios of engines to accommodate lower octane fuel with less lead.

The rate at which vehicle air pollution can be reduced is significantly governed by the rate at which new, low-emission cars replace old, uncontrolled ones. Emission rates also increase with the mileage and age of the vehicles.

Methods of Control

Efforts to reduce air pollution can take various forms :

(i) To oblige owners to install devices designed to bring emissions down. Such a fitting could be made a condition of renewing an annual licence or required when a vehicle changes hands.

(ii) Mandatory maintenance of emission control is another possibility. Periodic adjustments could be required to ignition timing and fuel mixtures; devices for controlling crankcase emissions could be compulsorily serviced or replaced, Vehicle owners could be obliged to have such maintenance performed at regular intervals and to show proof of it when applying to renew their annual licences.

(iii) Periodic inspection and testing of emission control systems to assure that emission levels of vehicles in use remain within allowable limits. The practice of testing (CO) carbon monoxide emissions at engine idling speed is common in many countries. More sophisticated exhaust emission tests, involving dynamometers and the measurement of HC (Hydrocarbons) and CO emissions during simulated drives, are being done in some countries.

(iv) Visual checks for smoke is the least expensive of the available alternatives. Although the smoke control has no value in reducing emissions of CO, HC and NO_x, it is useful for controlling emissions of particulates and reducing haze due to smoke.

The practicality of a large-scale emission testing and inspection programme for vehicles in service rests on 3 main factors :

(1) A test is needed that is cheap and quick, that can be applied to warmed-up cars and that gets results that correlate well with those from a full driving cycle.

(2) Test procedures that reveal what is wrong with cars that fail the inspection and that indicate what needs repairing are essential. So are simple manufacturers' maintenance instructions and manuals.

(3) Assuming that a short test capable of diagnosing troubles becomes available, it will be necessary to determine what reduction in emissions it is capable of bringing about, how much it would cost the government and the motorist and whether the resulting air quality improvements are worth the cost.

The potential emission reductions from inspection and maintenance cannot be determined precisely until more information is available about such factors as the rate at which emission control devices deteriorate in the interval between maintenance.

Health and Welfare effects of Automotive Pollution

Pollution of the atmosphere due to motor vehicles is viewed as a rising threat to the public health and to the welfare of the population, although there is no agreement on how serious and immediate this threat has already become.

CO is well known for its poisonous effects at high concentrations. It is absorbed through the lungs and reacts primarily with the hemoglobin of red blood cells. As an air pollutant, CO represents a potential danger to human health and safety. It decreases the oxygen carrying capacity of the blood.

HC represent the major class of reactive organic matter in the atmosphere that is responsible for photochemical smog. Through their reaction

intermediates the photochemical oxidation products, they are directly responsible for the eye irritation associated with photochemical smog and much of the characteristic vegetation damage.

NO_2 is a specific air pollutant associated with increased incidences of acute bronchitis in infants & children and acute respiratory disease in the entire family group. NO_2 has also been associated with damage to vegetation and corrosion of electronic components.

Lead is a biologically non-essential metallic element which is clearly toxic under conditions of prolonged and excessive exposure. Furthermore, lead accumulates in persons exposed to high atmospheric concentrations. Lead is absorbed through the gastrointestinal and respiratory tracts.

A wide choice of indirect measures can be employed to deal with air pollution. They can be grouped into :

(i) traffic and parking restraints

(ii) making more intensive use of cars (avoiding empty running)

(iii) staggering of work hours

(iv) improving the flow of traffic

(v) design and location of highways

Limiting the use of lead in motor fuel

A growing number of countries have decided to limit the content of lead in motor fuel. Their plans range from modest reductions to near-total elimination of lead additives, in some cases they have proposed to introduce one grade of lead-free low-octane fuel. There is disagreement whether present levels of air borne lead constitute a danger to public health.

However, many governments believe, it is desirable that present levels of airborne lead should not be exceeded, and should if possible, be reduced. Arguments for elimination of lead have also been made on the grounds that lead adversely affects engine performance. There are conflicting claims as to whether or not lead additions contribute to the build up of deposits in engine combustion chambers resulting in higher hydrocarbon emissions. It is generally agreed however, that lead can have adverse effects on the life of exhaust systems, spark plugs and crankcase oil. In any case, none of these effects are the determining factor in the decision to eliminate lead from fuel.

A number of factors essentially of economic nature have been advanced against a major reduction of lead content of fuel. The magnitude of cost involved would depend on the extent of reduction and whether the removal of lead is accomplished with or without lowering octane levels.

Lead additives

The purpose of lead additives is to raise the octane rating of motor fuel. It is the cheapest and easiest method of doing this. Lead also provides the refiner with great flexibility in maintaining octane levels if, for some reason, alteration in fuel composition is made necessary at some stage in the refining process.

Octane number is a measure of the resistance of a fuel to particular uncontrolled combustion phenomenon, known as detonation or "knocking" which can result in considerable power loss, severe engine damage and increased nitrogen oxide emissions. Knock can occur at either high speed or low speed depending on the octane number of the different components used in the fuel. The total fuel blend must be designed to avoid both of these conditions.

The octane number necessary for good combustion depends primarily on the engine's compression ratio. Generally, the higher the compression ratio, higher the octane number requirement, but greater the efficiency and therefore the better the fuel economy.

Different engine designs at a given compression ratio can require fuels with different octane rating. The octane number depends not only upon the compression ratio but also upon the combustion chamber geometry, valve configuration, ignition timing, mixture strength, coolant temperature, humidity of air, the altitude at which the engine is working and the restrictiveness of its exhaust system.

The average octane requirement of new cars have risen considerably since 1958, but in the last few years octane number requirement have remained relatively constant. Today, premium grade fuel stands at fairly uniform 98 to 100 - Research octane number (RON) in most countries with a lead

content ranging from 0.1 to 0.9 grams per litre. Regular grade varies more widely in octane rating with a low of 85 and a high of 96 and a lead content from zero to 0.8 grams per litre. A slight reduction in octane rating would be unlikely to interfere with the satisfactory operation of a high proportion of cars currently on the road and would make it possible for countries (like Sri Lanka) which at present permit a high level of lead in gasoline to lower their permitted levels by a small amount. More drastic reductions in lead would require changes that might take longer to implement. Such major reductions would require either

(i) the modification of car engines to operate on low lead, low octane fuel or

(ii) the modification of fuels so that they could retain their present octane rating.

The consequences of lowering engine compression ratio

Within limits the thermal efficiency of an engine increases with compression ratio. For a given engine design capacity, the higher the compression ratio, the greater the power output or alternatively the lower the fuel consumption for specific horse power out put. Conversely, lowering the compression ratio reduces the power out-put or raises the fuel consumption. To compensate for the power losses one must increase the size of the engine or its fuel consumption. The small high performance engine continues to be widely used in present day cars because of the demand for small cars and the need for fuel economy.

In high horse power cars a reduction in the compression ratio can be traded off against some of the excess power which they already possess. But for lower powered cars which do not have power to spare, a reduction to a lower compression ratio might mean increases in the size and weight of engines. This is turn would mean larger and heavier cars and more importantly, a greater specific fuel consumption leading to a higher lead, HC and CO_2 emission rates for vehicle/km, if not otherwise controlled.

Car manufacturers who lowered compression ratios of their cars to permit operation on lead free fuel might find themselves at a disadvantage compared to those who did not take such a step. Moreover, an engineering change in new cars would not allow an immediate reduction in fuel octane, as the need of many older cars must be satisfied with fuels of current octane levels.

The consequences of modifying fuel

Addition of lead is the cheapest and perhaps the easiest but not the only way, of raising octane numbers. Substantially, similar results are technically achievable through the blending of higher octane quality components. Some of the necessary blending components, however are not currently available in all countries.

Because of limited refinery capacity it would be impossible to produce sufficient quantities of high octane blending components to eliminate or drastically reduce lead in motor fuel immediately and still maintain present octane levels.

At the refinery, new facilities would have to be constructed to produce high octane fractions. The time and huge sums of money required to construct the new refinery facilities mean that this must be a gradual process. The cost of the refinery additions needed to produce high octane fuel will depend on the capacity and technical make up of existing plant, the amount of unused capacity for distilling high octane components and the degree of lead removal desired. The added cost of refining lead-free fuel would have a direct impact on the price of fuel.

Concern has been voiced that the limitation of lead additives could lead to large increases in the use of aromatics as a research octane booster and thereby cause possible increases in the emissions of photochemically reactive and poly-nuclear aromatic hydrocarbons and of phenols and adversely affect the engine performance because of inadequate boost in motor octane number (MON). A fuel which has its lead content replaced with aromatics to give it the same research octane number (RON) will not necessarily provide the same resistance to detonation under normal driving conditions. There appears to be a practical limit on the amount of aromatics that can be put in the fuels. Unless an extremely rigid fuel lead reduction schedule were to be adopted, the concern over aromatic increase is probably not justified.

Health effect of airborne lead

Most of the lead in the urban air appears to come from motor vehicle fuel. According to tests made with American automobiles about 70 - 80% of lead from fuel consumed leaves the exhaust system of the automobiles and reaches the environment.

Estimates of the amount of air breathed by the average adult vary from 10-23 cubic metres per day. The amount of lead which enters the respiratory tract, the amount deposited and retained there, and the quantity finally absorbed is dependent upon the size, shape and chemical composition of the particles. Several estimates of particle size for exhaust lead have been made and there is general agreement that most particles are less than 1 micron in diameter. Estimates obtained from human experiments of the amount of lead absorbed generally vary from 25 to 50% with the maximum rate of absorption for particles of medium size 0.6 - 1.0 μ.

Of interest in the consideration of the health risks of leaded fuel are the special risk groups, children, pregnant women, persons occupationally exposed etc.

There remain two important considerations in any examination of the health effects of atmospheric lead. The trends in the increased number of motor vehicles and in the increased gasoline octane rating suggest that if no restrictions are placed upon the lead content in gasoline, we will be subject to higher levels of lead in the atmosphere than at present.

Secondly, although no chronic effects have yet been demonstrated in response to levels of lead currently present, the amount of atmospheric lead has increased greatly in the past decade and it may be too early to detect any delayed effects.

The technology of vehicle emission control

Modifications to the conventional internal combustion engine.

The petrol-fueled internal combustion is an inherently high emission propulsion system. The high emissions are caused, to a major degree by the fuel itself and the difficulty in bringing about complete combustion. In addition to reducing exhaust emissions by adjusting, servicing and replacing engine parts which affect combustion (e.g. carburettor, ignition system), a measure which could be applied to older as well as to new motor vehicles, several other approaches have been considered for attaining low pollutant emissions from motor vehicle engines. They include techniques for bringing about more complete combustion, either by actions affecting the fuel supply to the engines or the combustion process itself, and techniques which act on the exhaust gases once they have left the engine.

Modification of combustion chamber design

A very thin layer of gaseous mixture which makes contact with the relatively cool combustion chamber surface does not burn. More nearly complete combustion of the full cylinder charge is promoted by modifying the combustion chamber design to reduce surface to volume ratio by minimizing the crevices. This has to be done by the engine manufacturer.

Modification of induction system

CO in exhaust results from insufficient O_2 in the fuel-air mixture and consequent incomplete combustion. Incomplete combustion is also an important source of HC. Leaner air-fuel mixtures to assure more complete combustion can be achieved by converting more of the liquid gasoline into vapour form and by providing for improved fuel-air mixing and distribution among the cylinders. Air-fuel induction systemscan be adapted to provide heated intake air for more uniform carburettor inlet temperatures thus allowing the use of leaner fuel-air mixtures. More uniform distribution of the fuel-air mixture to the cylinders can be accomplished through intake manifold heating or through design changes. Unfortunately, modifications of induction systems which improve combustion and reduce HC and CO emissions also raise temperatures and contribute to higher nitrogen oxide emissions.

Carburettor modifications

The carburettor is a key element in effective emission control because of its role in metering the fuel in proper proportion to inlet air. Precise fuel metering, in accordance with changing engine requirements, makes possible operation with lean air-fuel mixtures. Carburettors can be designed with stronger fuel metering signals and closer calibration tolerances to assure better fuel mixing preparation.

Choke modifications

Gasoline in liquid form does not burn. Therefore when an engine is started cold, an extra amount of gasoline is needed in order to obtain enough vaporized hydrocarbons to mix with air and provide a combustible mixture at the spark-plug. The carburettor choke supplies the added fuel. However, the unvaporized hydrocarbons pass through the engine unburnt. By tailoring choke action to car requirements, enrichment during starting and warm-up can be made compatible with satisfactory drivability over wide temperature range (this has been done on majority of modern cars). Changing the fuel to achieve greater vaporization could obviate the need for the choke or drastically reduce its use.

Ignition system modification

Spark retardation can be used to reduce emissions of HC and nitrogen oxide. Electronic ignition systems have been developed which will improve control of spark timing at all engine operating conditions, facilitate adjustments of spark timing on vehicles in use, and have greater reliability. Retarding ignition timing results in more fuel being burned during the exhaust phase of the combustion cycle. Accordingly, some loss in power and fuel economy results.

Lower compression ratio

The use of high compression ratios improves engine efficiency and results in more power output for a given amount of fuel. Combustion temperatures are high, however, causing high emissions of nitrogen oxides. The octane requirements of high compression ratio engines are high, necessitating the use of lead or fuel modification.

After burner

The after burner, designed to oxidize unburnt HC and CO in exhaust gases, includes a precombustion chamber in which secondary air and fuel are spark ignited to provide thermal energy for the associated reaction chamber. The reduction in CO and HC pollutants only from vehicle exhaust when after burners are installed is estimated (in America) to be some 70 and 80 per cent, respectively. Over heating is a serious handicap.

Air injection

After the gases have left the combustion chamber air is injected as close as possible to the exhaust valve where any CO and HC present are hot enough to ignite immediately and their oxidation is thus completed. Changes of cylinder head and exhaust manifold are required. Since control of nitrogen oxides during the combustion process has tended to increase HC and CO emissions, interest in exhaust port air injection is reviving.

Thermal reactors

A thermal reactor functions as a combustion chamber outside the engine and normally appears in the form of an oversized exhaust manifold. Thermal reactors receive the hot exhaust gases from the engines, retaining as much heat as possible with insulation. Additional heat is generated by oxidation of CO in the exhaust gases. High CO concentrations are obtained by operating the engine with rich fuel mixtures. Such reactors are known as "rich thermal reactors". When designed for rich fuel-air mixtures to promote nitrogen oxides control, there is a substantial fuel penalty. In a "lean thermal reactor" system, the carburettor is set lean so that the exhaust is inherently oxidizing. Emissions are generally higher than from rich reactors.

Because of extremely high temperatures that can be reached, materials of satisfactory durability must be used. Special protective systems would be needed to prevent damage to engine through over heating.

Catalytic converters

Catalytic converters are devices designed to convert exhaust gases into harmless chemicals through chemical oxidation or reduction. The catalyst bed generally consists of an active material deposited in a thin layer on an inert support. Platinum or transition metal oxides are the most common active materials. A two stage catalytic converter can be employed to reduce oxides of nitrogen and to oxidize HC and CO. A rich fuel-air mixture can be used in the engine to give an exhaust containing large quantities of CO which chemically reduce NO_x in the first stage of the converter. Air can then be added to oxidize CO and HC in the second stage. This device has a high potential for efficient emission control.

The catalytic converter is a relatively low temperature device and need not be located in the engine compartment. Underbody modifications may be required however for best insultation and adequate ground clearance.

N.B. A considerable reduction in pollutant emissions can be obtained by converting petrol engine to gas operation. Gaseous fuels such as liquified petroleum gas (LPG), liquified natural gas (LNG) or compressed natural gas (CNG) can be used.

Diesel engines

The emissions of CO and HC from diesel engines are much less than those of gasoline engines, although nitrogen oxides emissions are the same. Diesel engines emit a black or blue smoke if they are poorly designed, tuned or maintained and the exhaust gases can have an unpleasant odour. However diesel smoke can be reduced substantially by using additives, by proper engine maintenance, avoiding over-loading, engine derating and adherence to proper fuel specifications. Heavy smoke emission is caused due to poor maintenance such as faulty injectors, incorrect pump timing etc. Diesel engines also emit SO_2 if the diesel fuel contains (S) sulphur as an impurity. Auto diesel is a fuel used mainly as a transportation fuel and is used by both CTB and CGR. As auto diesel supplied by petroleum corporation is not free of S (contain about 1.5%) exhaust gases of bus engines as well as locomotive engines contain small percentage of SO_2. Good S-free or less S diesels are obtained from paraffin-based crude oils and also by Hydrocracking of waxy distillates.

Electrification of railway

The case for the electrification of the railway rests on,

(i) The inevitable nature of the "fuel crisis" -diesel becoming hard to get and highly priced.

(ii) the inherent superiority of electric traction - low energy costs, low maintenance costs, cheaper and better operation all arising therefrom.

(iii) the need to improve and expand our railway network, both in the suburban area and on the trunk routes.

and (NB.) (iv) Electric traction produces no atmospheric pollution and less noise than any other mode of railway bulk transport.

Electrical interference is produced which requires supression to be provided on communications and signalling equipment. This electrical pollution can be controlled by modern technical methods and is seldom a nuisance or a problem to the general public. Overhead structures and wires are required but are generally of low height and today of light construction. The effect on the environment is certainly more acceptable than steam or diesel-operated railways.

An economic feasibility study on electrification of our railway has been done as far back as 1974 by a team of French railway experts. In 1980/1981 a team of Japanese consultants completed the preparation of design and specification for the electrification of revised network of Colombo suburban area. As the costs estimates were on the very high side (about Rs. 6000 million), and the funds were not available, Railway department has proposed to implement this project in two stages. First stage covers the Panadura to Veyangoda double line area for which a project report has been prepared and it has been included in the next 4 year plan.

Second stage covers Ragama to Negombo, Veyangoda to Polgahawela and Panadura to Kalutara South and this stage to be completed later.

N.B. With electrification a considerable increase in traffic for railway is expected due to transfer of traffic from road to rail. This is estimated to be a 10% increase initially followed by a 2% increase annually. This means a proportional reduction in usage of road vehicles and a corresponding reduction in air pollution caused by road vehicles.

J.M.L.M. Peiris

Transportation Superintendent
(Motive Power)
Ceylon Government Railway

Annexure D.

POLLUTION CAUSED BY VEHICLE EXHAUST EMISSION GASES

The prime movers of motor vehicles are internal combustion engines that fall into two main categories. These two categories are spark ignition engines utilising petrol as fuel and compression ignition engines utilising diesel as fuel.

2. The Sri Lanka Transport Board has about 7500 buses comprising of three principle makes, viz:, Leyland, Tata and Isuzu. The entire fleet of buses in the S.L.T.B. are equipped with the compression ignition type of engines or more popularly known as diesel engines.

3. In a motor vehicle where the engine is functioning in the proper manner, the gases emitted by exhaust should be within the permissable limits, and would hardly be visible. In a diesel engine, the exhaust emission gases generally consist mainly of the residual gases due to combustion of the air-fuel mixture. However, the burning of the engine lubricating oil within the combustion chambers of the engine also takes place to some extent, but would be of a low degree when the engine is in good condition.

4. Excessive and dense black smoke from the engine exhaust system of a motor vehicle equipped with a diesel engine, is evidence of incomplete or partial combustion of the air-fuel mixture within the combustion chambers of the engine. Such emission is commonly known as 'belching'. There are several factors leading to this cause. Basically, they are as follows :

   (1) Quantity of fuel injected and the timing of injection
   (2) Atomization of the fuel being injected
   (3) Degree of heat generated during the compression cycle

4.1 The first two functions are performed by the fuel injection equipment of a diesel engine. This equipment comprise of the fuel injection pump and governor, delivery lines and the fuel injectors of each cylinder. The metered quantities of fuel required at various engine speeds and the injection timing are specified by the vehicle manufacturers.

4.2 Injecting a quantity of fuel more than the specified amount for that speed would lead to incomplete or partial combustion resulting in the emission of smoke. Not injecting the fuel to the cylinders at the correct time would also lead to incomplete or partial combustion, within the cylinders. Although these two aspects are set according to specifications at the time of manufacturing or reconditioning of a diesel engine, the original settings can get altered while in service.

4.3 The proper atomization of the fuel being injected to the cylinders, is important. This depends mainly on the performance of the individual fuel injectors injecting the fuel to the combustion chambers of the engine. Here again, the original settings such as the injection pressure and the performance of the injector can change while in service. If the fuel injectors are not performing their functions properly, it could also lead to incomplete or partial combustion within the combustion chambers.

4.4 During the compression cycle of the engine, if the compressed air does not attain the required temperature, proper combustion of the air-fuel mixture within the combustion chambers will not take place and result in incomplete or partial combustion. The main reason for this cause is the inability to develop the required final pressure during the compression cycle. This happens as a result of excessive wear on cylinder bores, pistons and piston rings. This generally takes place during the later stages of the engine life and would combine with high consumption of lubricating oil. At this stage the engine should be overhauled.

5. The maintenance of the fuel injection equipment of a diesel engine in service, is therefore very important. Periodical checking of the fuel injection pump and injectors in order to assess the performance would therefore become necessary. Any faults detected on these periodical checks must be rectified.

6. The Sri Lanka Transport Board has a scheme of preventive maintenenace in force, for the fleet of buses, and the fuel injection equipment is one major item included in this scheme. It has become necessary for the S.L.T.B to stock spare parts for the fuel injection system for three makes of buses as mentioned in para 2 earlier, at the respective workshops and depots. Although the fleet of buses in the S.L.T.B. is of three principle makes, there are more than six models of engines having different types of injection equipment.

7. The S.L.T.B. has been aware of the heavy exhaust emission from some buses, for a long time, and has been making every effort to eliminateit. The S.L.T.B. has a special unit based at the Head Office that assists the Workshops and Depots in the overhaul and maintenance of fuel injection equipment. However, the overhaul and proper maintenance of the fuel injection equipment are very often affected due to the shortage of the necessary spare parts. This is mainly due to the various financial constraints the S.L.T.B. has been faced with from time to time.

B.D.Y Seneviratne,
Director Technical/General Manager,
Sri Lanka Central Transport Board

Annexure E.

Letter from Dr. C.G.Uragoda

Central Chest Clinic
385 Deans Road
Colombo 10.

24th June, 1983.

Dr. R.H. Wickramasinghe
Central Environmental Authority
Maligawatte New Town
Colombo 10.

Dear Dr. Wickramasinghe,

I am glad to hear that the Hon. Prime Minister has appointed a Committee to examine pollution caused by vehicle fumes.

Hydrocarbons, lead, sulphur dioxide, nitrogen dioxide and carbon monoxide are all potentially harmful substances which are discharged to the atmosphere by the combustion of petrol and diesel. 3,4 Benz pyrene has been incriminated in the causation of lung cancer. Classical studies in England have shown that the incidence of lung cancer is higher in the urban than in the rural population, and one of the factors in this disparity is the increased levels of 3,4 benz pyrene in the motor fumes found mostly in the urban areas. It may be mentioned that this hydrocarbon is also found in tobacco smoke.

Long term exposure to concentrations of sulphur dioxide as low as 0.6 to 2.6 mg/m^3 may cause symptoms in asthmatics and chronic bronchitics.

Nitrogen dioxide is a particularly hazardous gas which may cause death in high concentrations. Short term exposure to more than 1.8 mg/m^3 may cause irreversible lung damage.

In view of the long term potential hazards of motor fumes most developed countries have taken measures to minimise atmospheric pollution by motor vehicles. Since the risk is not dramatic but slow acting over many years, complacency should be avoided. Adequate steps should be taken now before the situation deteriorates.

Thanking you,
Yours sincerely,

Dr. C.G. Uragoda
Physician in Charge

Annexure F.

Strategies for Pollution Control

Developing strategies for minimizing the addition of excessive amounts of pollutants to the environment has been a major challenge for industrialised societies.

Different strategies are being evolved with varying applicability to different circumstances and needs. For example, some differences in pollution control strategies exist between Britain and other Common Market countries; between these, emphasis may vary between environmental quality objectives and uniform emission standards.

Since the lay citizen may not be aware that different strategies have been and are continuing to be devised to tackle the problem of pollution control, the present very brief account was prepared to highlight this aspect of environmental studies and to stimulate creative thought in this area, particularly in respect of strategies for controlling vehicle exhaust emissions in Sri Lanka.

Requirements for pollution control include the identification of the chemical pollutants being emitted from a given source and the estimation (as far as is practicable) of the amount of each constituent.

Certain chemicals may, of course, be noxious even in small amounts and the analytical facilities for the determination of some pollutants may be far beyond the financial resources of a small company or its technical consultants.

Furthermore, analytical instrumentation may just not exist at the present time for the measurement of low levels of certain pollutants.

It is noteworthy that one reason that more and more pollutants are being detected today in environmental samples is that sensitive instruments have been developed in recent years capable of picking up evidence of these chemicals in trace amounts, which would have passed undetected earlier.

A factor related to technical capability is the availability of adequate trained staff. Some are necessary for research and development-type activities, such as identifying pollutants or investigating processes for reducing the pollutant content of an effluent.

Others are needed for functions such as monitoring pollutant concentrations in effluents. In Sri Lanka, both of these categories of technical staff are in short supply. However, we can supplement local research to some extent with data and information based on researches and experiences overseas.

While advantage must be taken of information from overseas, the strategies evolved to cope with pollution must form an organic part of the local scene. In particular, factors which are economic, social, legal, administrative and political must be taken into account.

These questions are common occurrences in industrialised countries and strategies are discussed and developed with inputs of professionals from various disciplines, such as scientists, economists, administrators and lawyers.

Analyses of anticipated costs and benefits are an important part of a proposed programme, which is then developed to meet the needs and circumstances of the particular case.

One may, as an example, cite the case of a multinational, slow moving river, such as the Rhine, which, in some respects, gives rise to problems different to those caused by pollution of the fast following rivers in Britain.

As regards motor vehicle emissions, the benefits to be expected from a control programme is even more difficult to quantify than its costs. For an industrialised country, benefits can include the delaying of deaths, better general health, reduction of annoyance, reduced effects on agricultural crops and forests and the reduction of deterioration of materials.

Debate

In Sri Lanka, given the extent of belching by some vehicles, considerably improved fuel economy, improvement of visibility on the highway and reduction in accident rates and improvement of property values would be among the added benefits.

A study completed in 1974 by a collaborative effort of the National Academy of Sciences of the USA and the US National Academy of Engineering reckoned that, for the US, over the period 1975 to 2010, the costs of such a programme could be around $ 126 billion and the benefits around $ 137 billion.

The actual figures could, however, be considerably different, depending, for example, on the introduction of new technology or of improved strategies for pollution control.

Of strategies for pollution control, heated debate has been taking place in recent years over the relative merits of the "effluent standards" versus "effluent fees" approaches.

Since it is possible that these two approaches may suit different needs or circumstances, a brief description of each is of interest.

The "effluent standards" approach necessitates the setting of maximum levels for each emission based on currently accepted estimates of what the environment can tolerate of a given pollutant. The tolerable amounts may vary from place to place depending on one or more of a variety of factors, including the geographic characteristics of the area.

Another noteworthy point is that the general level of pollution can increase even where effluent standards are enforced, if the number of sources increases (eg. the increasing population of motor vehicles worldwide).

The "effluent charge" or "effluent fee" approach is often supported by economists, but is, however, not easily understood as a pollution control measure; nor is it generally popular with the public.

An effluent charge system means that a polluter pays a fee proportional to the amount of pollutant he discharges into the environment.

In setting the fee, the regulatory agency would attempt to estimate what it would cost the polluter to clean up his effluent and would accordingly set the effluent fee high enough to act as an incentive to clean up as much as is economically possible of what is being emitted.

Very often the initial purification (or abatement) stages are much less expensive than removing residual low levels of a pollutant from an effluent.

Thus, as an example, one abatement process used for removing particulates from an emission of an industry may cost annually Rs. 750 per per cent abatement of this pollutant in the efficiency range of 80 to 90 % control.

However, in using the same process to achieve 90 to 99% control, the annual abatement costs may rise steeply to Rs. 6000 per per cent. Similarly, a different process may have an annual cost of Rs. 5000 per per cent abated in the range from 90 to 95 %, but Rs. 7000 per per cent in the range of 95 to 99.5% efficiency.

It has been observed that the "effluent standards" strategy may determine pollution levels but leave costs of cleaning up undetermined, while "effluent fees" ascertain clean up costs but do not stipulate the level of pollution.

With the "effluent fee" system, the polluter usually reduces the pollution emitted to the level where the fee he pays is equal to what it would cost him to purify the effluent by another step.

If the fee is high, the polluter would save money by making an investment to clean up his effluent some more.

The relative merits of the "effluent standards" and "effluent fees" strategies depend, as has been indicated, on the relevant conditions

and circumstances. With some types of pollution, damages may rise sharply once a threshold level of pollution is exceeded. Again, with some types of pollution, clean up costs vary only little with clean up levels.

Incentive

In both these situations, an "effluent standards" strategy may prove more desirable than "effluent fees". A major practical difficulty that is often experienced is the uncertainty of making monetary estimates of costs and damages and of calculating and setting fees correctly.

A possible compromise which has been proposed is a mixed strategy of standards with fees or penalties in the circumstances of the defined standards being exceeded.

What contributions could these various strategies being developed make to the practice of pollution control in Sri Lanka ?

Initially, it must be reiterated that we do not have the numbers of technically experienced personnel nor the local data and information to make it feasible at present to contemplate going over in an extensive way to the setting of effluent fees and administering such a programme very readily.

Moreover, while an "effluent standards" system may be organised to be operated with much less monitoring, it has been noted that continuous monitoring for use in conjuction with an "effluent charge" programme is expensive and often impracticable even in an industrialised country.

An "effluent fees" strategy has been discussed - initially, principally by economists - in connection with the control of vehicle exhaust emissions from new cars.

This was partly to provide a better incentive for appropriate research and development, which the "effluent standards" approach does not, for various reasons, seem to have achieved very satisfactorily in its progress over the last twenty five years.

This aspect is, however, less relevant to Sri Lanka's circumstances, due to the absence of local motor vehicle design and manufacture. However, establishing an "effluent fee" schedule for vehicles in use, in conjunction with annual testing, could encourage the vehicle owner to carry out regular maintenance of the engine and exhaust system rather more effectively than is generally the case today.

The fees set could then take into account both the emissions per mile and the distance travelled for the year.

However, this would necessitate a tamper-proof or sealed odometer and other parts, in addition to various other requirements, such as coping with each of several pollutants in vehicle exhausts and determining these annually.

Another alternative is the "two-car strategy", where cars used in high pollution areas would have to meet stricter emission standards than those used elsewhere.

While available resources in Sri Lanka may not permit application of the "effluent fees" strategy to the control of vehicle exhaust emissions, this approach may be retained for possible consideration in connection with other sources of pollution.

It must, however, also be kept in mind that the "effluent fees" strategy has not found widespread support even in the industrialised countries, where technical back-up is more readily available.

Perhaps a "mixed effluent standards - fees" strategy or a further development of the effluent fees strategy will eventually find greater acceptance.

In any event, it is advisable to exercise prudence in the selection of appropriate strategies in combatting environmental pollution.

Dr. R.H. Wickramasinghe
(reproduced, with permission,
from the "Sunday Observer"
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